

# MOAI OF EASTER ISLAND: A QUEST FOR IDEAL PROPORTIONS

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THE MONOLITHIC SCULPTURE OF Easter Island is a key aspect of its unique cultural heritage. *Moai* played a very important role in the prehistoric Rapanui society. The ceremonial platforms adorned with the stone giants were sacred places where the supernatural world met the world of humans. The welfare of the population was dependent on the magical powers, flowing from the heavens to the people through the spiritual vessels – hereditary island kings and the sacred stone monuments, *moai* (Van Tilburg 1994:128-9).

It seems natural to assume that, to perform properly such an exceptional ritual function, the statue had to meet certain standards. This might have been of special importance for the ceremonial places bearing several images: all the *moai* belonging to the site had to amplify the *mana* of each other, forming a kind of perfect spiritual “choir.” Such a suggestion seems feasible when one beholds the beautifully reconstructed Ahu Nau Nau and Ahu Akivi, featuring harmonic and coherent arrangement of the statues of the same style, size and proportions.

Following the same point of view, the largest ritual platform of the island, Ahu Tongariki, presents a slight problem. Fifteen majestic *moai* proudly towering on its enormous, almost 100 meter platform, are masterly hewn in the similar style but they differ significantly in height, ranging from 5.6 to 8.7m (Ramírez and Huber 2000:81). If uniformity were so crucial for the ancient Rapanui, the short distance from Rano Raraku quarries would significantly simplify the problem to supply the site with a set of fifteen identical statues. Even if it were decided at a certain moment to erect larger images on the *ahu*, the smaller *moai* could have been replaced for brand-new taller ones, preserving the visual homogeneity of the site. As this did not happen, one may assume that equal heights of the statues were not the decisive harmonizing factor. Then, the easiest way to make a coherent ensemble out of size-varying units was to keep them all in accordance with a certain fixed proportion ratio.

If such a special proportions ever existed, it had to be “embedded” into the statue in the very beginning of the carving process. To begin the work, master carvers first looked for a place suitable to accommodate a would-be *moai*, outlined the contours of the image, either *en face* for the horizontal surface or in profile for the vertical wall carving; in some instances, a block of a required size was previously cut from the mother rock, and the statue was modeled from it (Skjølsvold 1961:367). The hypothetic “special proportion” determining the proper shape of the statue should be equally applicable in all three cases mentioned, which immediately exclude all width-related ratios as unavailable right at the beginning of carving process, when the statue was intended to be “extracted” from the vertical wall. As special emphasis of the whole figure was related to its head, it is logical to assume that the ratio of the head length to the total height of the statue could be a proportion-determining factor.

As we know, the head, in general, composes 1/3-1/2 (i.e. 0.33-0.5) of the total height of the *moai* (Van Tilburg 1994:131); other sources report the proportionality coefficients  $2/5 = 0.4$  (Skjølsvold 1961:346) and  $3/7 = 0.429$  (Métraux 1940:293). As the statues of the coastal *ahu* are weathered or damaged to various degrees, one can expect to have a better chance of deriving the original proportions from the metric data collected from the intact statues at Rano Raraku, excavated by the Norwegian Archaeological Expedition (Table 1). As one can see from the table, four of eight calculated face/total height ratios yielded the result of 0.38, and the others gravitate around the value of 0.42. The reproducibility of the former ratio makes one suspicious about the presence of certain regularity rather than being a mere coincidence.

One particular segment division technique that results in the very similar proportion ratio has been known for centuries. It is the so-called golden section, used by ancient mathematicians and artists to determine the side of a regular decagon, inscribed into a circle of a given radius. The longer and shorter parts  $M_1$  and  $M_2$ , obtained by a golden section of a segment  $M_0$  relate to each other as (Bernshtein and Semendyaev 1962:161):

$$1. \quad \frac{M_2}{M_1} = \frac{M_1}{M_0} = \frac{\sqrt{5}-1}{2} = 0.618$$

At the same time, the ratio of the shorter part  $M_2$  to the whole segment  $M_0$  is defined with the proportionality coefficient:

$$2. \quad \frac{M_2}{M_0} = \frac{M_2}{M_1} \cdot \frac{M_1}{M_0} = \left[ \frac{\sqrt{5}-1}{2} \right]^2 = 0.382$$

which is very close to the face/total height ratio obtained for the statues 49, 86, 93, and 240 (Table 1). Indeed, for *moai*

Table 1. Statue numbers after Cristino et al. 1981 together with those assigned by Padre Sebastian Englert; the metric data after Skjølsvold 1961:348-360 and Van Tilburg 1986: 686

Statue number	Height H, m	Face length F, m	F/H ratio
49/PE 263	4.85	1.85	0.381
77/PE 280	5.75	2.42	0.421
78/PE 284	6.80	2.85	0.422
61/PE 285	7.15	1.61+1.34	0.413
86/PE 290	5.80	2.20	0.379
93/PE 295	11.40	4.30	0.377
240/PE 367	5.75	2.20	0.383
265/PE 400	6.0	2.69	0.448

*Hiave* (No. 93) featuring the coefficient  $F/H=0.377$  (the largest deviation from more precise value 0.382), the estimation of face length will be  $11.4\text{m} \times 0.382 = 4.35\text{m}$ , resulting in an error as small as 5cm (i.e. 1.2% of the actual measurement). But, if a golden section was used by the ancient carvers, how could they divide the segment with a required proportion?

There are several methods for the golden section of a segment (Bronstein and Semendyaev 1962:161) involving construction of the circles with the radius  $M_0$  (in our case, the height of the image), which surely would not work at Rano Raraku quarry, where the statues sometimes were carved in very tight (surrounded by walls) locations, or even in niches. Simpler methodology, suitable for narrow-space implementation, is based on the construction of a rectangular triangle with the sides  $M_0$ ,  $M_0/2$  and hypotenuse.

Figure 1 illustrates the suggested sequence of steps, allowing two master carvers  $M_0\sqrt{5}$  equipped with a rope to perform a golden section of the given segment. In the first step, the desired height of image  $M_0$  is laid off along the perpendicular to the base line of a would-be *moai*. Then, one *maori anga moai* doubles the rope and forms a triangle side with the length  $M_0/2$ , perpendicular to the lengthwise segment (Figure 1, step 2). Marking the required points on the stone surface or using small rocks for this purpose, two people can easily form the proper hypotenuse; the end of a doubled rope section would mark the desired ratio 0.618, ready to be translated to the lengthwise image line  $M_0$  (Figure 1, steps 3, 4). If further subdivisions  $M_i$  were required, one could re-iterate the whole

process, so that

$$3. \quad M_i = \left[ \frac{\sqrt{5}-1}{2} \right]^i M_0$$

On the other hand, there is a simpler solution

$$4. \quad (M_{i+1} = M_{i-1} - M_i, (i = 1, 2, 3 \dots))$$

Therefore, having a stick or a rope representing  $M_0$ , it would suffice to cut it into sections with the lengths  $M_1$ ,  $M_3$  and  $M_5$  to obtain the whole measure set  $M_{0-6}$  (Figure 1), where  $M_2 = M_1 - M_3$ ,  $M_4 = M_3 - M_5$ , and  $M_6 = M_3 - 2M_5$ .

If the measures  $M_i$  could be expected to define some proportions of the *moai*, one should hope finding them in the frontal or side image projections, reflecting the initial draft of the statue made by the master carver. Direct measurements may yield larger values for the inclined details (e.g., nose) changing the proportions we are looking for. The best approximation of the orthogonal *moai* projection is a picture taken with a telephoto lens from a distance to diminish the perspective distortions. Figure 2 shows photographs of Easter Island statues, taken by the author. All the images are brought to the same scale, making the height of each *moai* equal to  $M_0 = 1000$  arbitrary units.

As was expected, the golden section of the initial segment into  $M_1=618$  and  $M_2=382$  revealed good correlation with the chin of the statues (Figure 2, scale A). Surprisingly, all main *moai* dimensions show a good agreement with the

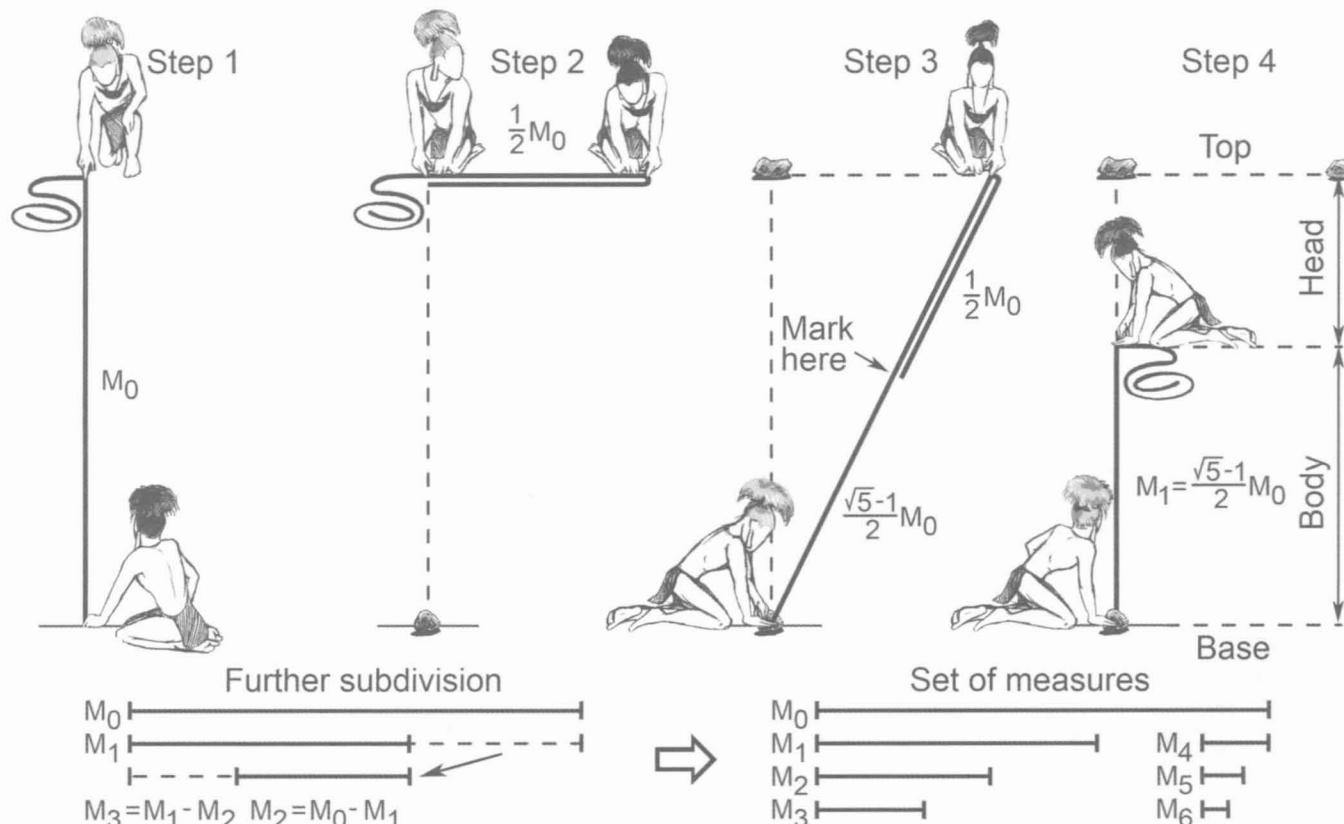


Figure 1. Suggested golden section algorithm and further subdivisions to obtain the measure set  $M_i$ .

lines corresponding to the subsequent segment subdivisions. For example, measuring the distance  $M_2$  from *moai* base one will hit the level of its nipples. Stepping down from the latter by  $M_3$  along the vertical axis of the statue one will find the navel; making the same procedure starting from the top of the head, we'll discover either tip or the bottom of the nose (Fig. 2, scales B, C). Vertical projection of the nose positively agrees with the measure  $M_4$ , as well as the distance from the level of the nipples line to the base of the neck and the vertical difference between the positions of the navel and elbows (Figure 2, scales D-F). Measure  $M_5$  corresponds to the height of the neck, to the distance between the corner of the eye and the top of the head (Figure 2: D, E). Perplexing disproportional placement of the mouth (Van Tilburg 1994:133), exaggerating the lower part of the face so that the statue looks like a portrait of a bearded person (Heyerdahl 1975:100), acquires a clear geometric interpretation, being separated by the distance  $M_5$  from the chin (Figure 2, upper scale F). The height of the loincloth *hami* varies for Tongariki and 'Anakena statues, but in both cases it can be positively determined by the distance  $M_5$ , measured from the base or the navel of the statue (Figure 2, D, E).

Moreover, horizontal *moai* proportions also seem related to the measure set  $M_i$ . In particular, for the Ahu Akivi image, the width of the nose measured at the nose bridge and at the nostrils agrees well with  $M_5$  and  $M_4$ , respectively. The latter also positively correlates with the length of the mouth. Overall head width is close to  $2M_4 + M_5$ ; the width of the body is similar to  $2M_3$  (Figure 2, scale G). It is tempting to assume that the characteristic horizontal proportions describing the statues of different height/width ratio could be also defined by a certain combination of  $M_i$ .

The reader can easily investigate the proportions of Easter Island statues using the excellent long-distance photos published in the richly illustrated book by Ramirez and Huber (2000:59; Ahu Vai Uri, :82-84 and :88-89, Ahu Tongariki, :96 and :99, Ahu Nau Nau, :111, Ahu Huri A Urenga, :71, Rano Raraku) and the numerical data from Figure 2. For example, the breath-taking aerial of the quarry shows the frontal view of the largest *moai*, El Gigante (actual length 20.9m, Skjølsvold 1961:366). The height of the statue in the photo is equal to 14mm, hence its face length ( $M_2$ ) is expected to be  $14 \times 382/1000 = 5.3\text{mm}$ , the nose ( $M_4$ ) will be verifiable from the same photo.  $4 \times 146/1000 = 2\text{mm}$  and so on, which is easily determined.

The metric data for several statues located at different sites (after Van Tilburg 1986:612-700 and Mulloy 1961:109) are presented in Table 2 together with the dimensions calculated according to the measures  $M_i$  relative to the statue height  $M_0$ . As one can see, all the examples are in agreement between the measured and predicted data.

But how it is possible to explain the deviations in the face/total height ratio for the excavated Rano Raraku statues No. 77, 78, 61 and 265 (Table 1) in the framework of golden section hypothesis? As we know, the head of the image was usually carved first (Skjølsvold 1961:367); if some serious material flaws like cracks and large lapilli appear to spoil the appearance of the *moai*, the sculptors had to abandon the half-finished statue (Métraux 1940:292). But, it is hardly believable that, after the huge effort invested in the sculpture, it would be discarded without any attempt to correct the situation. If the defect was found close to the basal part of the statue, it seems logical to assume that the height of the image could be sacrificed, thus saving the finished upper body. If

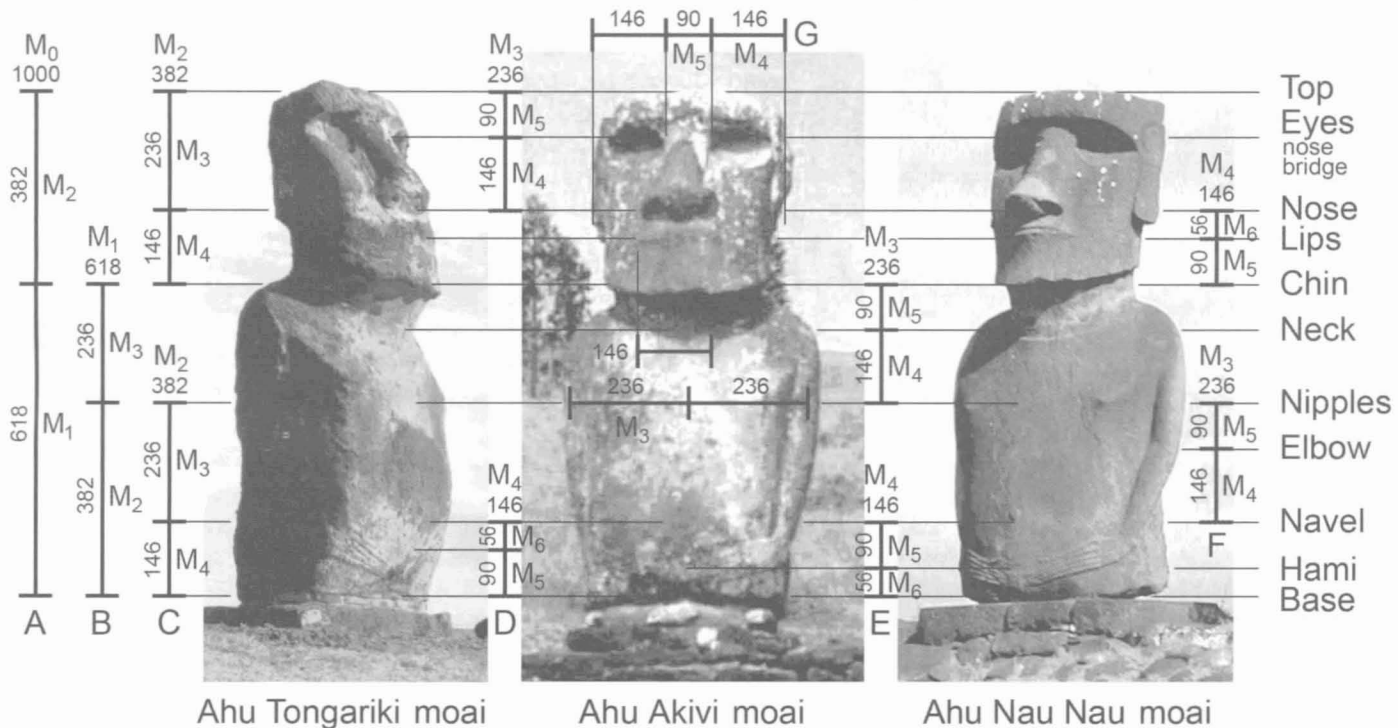


Figure 2. Proportional subdivision of three Easter Island statues scaled to equate their height to 1000 arbitrary units. Numerical values are rounded towards the nearest integers.

Table 2. Measured and predicted metric data for several Easter Island statues.

Statue	Height $M_0$ , m	Face, m	Other measurements, m
<i>Hoa Hakanana 'ia</i> British Museum	2.42	n.a. $M_2=0.92$	length, ear: total, 0.54 ( $M_3=0.57$ ), lobe, 0.36 ( $M_4=0.35$ ), ear body, 0.18 ( $M_5=0.22$ )
86-04 / PE 107 Ahu Nau Nau	3.05	1.13 $M_2=1.16$	width, shoulders: 1.49 ( $2M_3=1.44$ ); length, ear lobe: 0.44 ( $M_4=0.44$ ); width, nose bridge: 0.29 ( $M_5=0.28$ )
06-255-01 / PE 580 Ahu Hanga Tee,	4.14	1.60 $M_2=1.58$	length, ear: 0.98 ( $M_3=0.98$ )
02-210-06 / PE 625 Ahu Vinapu I	4.40	1.68 $M_2=1.68$	width, face at jaws: 1.30 ( $2M_4=1.28$ ) length, ear: 1.06 ( $M_3=1.04$ )
14-548-01 Ahu Tongariki	6.08	2.35 $M_2=2.32$	total length, ear: 1.43 ( $M_3=1.44$ ), width, nose: 0.89 ( $M_4=0.89$ ); length, <i>hami</i> : 0.56 ( $M_5=0.55$ )
PE 04-01 <i>Paro</i> , Ahu te Pito Kura	9.89	n.a. $M_2=3.78$	width, shoulders: 2.90 ( $2M_4=2.89$ ); length, ear: 1.43 ( $M_4=1.44$ ); width, base: 2.70 ( $3M_5=2.68$ );
12-03-02 / PE 574 Ahu Hanga Te Tenga	9.94	3.81 $M_2=3.80$	width, face at jaws: 1.80 ( $2M_5=1.79$ ); width, nose bridge: 0.56 ( $M_6=0.55$ )

the harmonic proportions had a crucial meaning for the *moai*, its height could be shortened for one of the characteristic measures trying to save the proportions too. Using the measure set  $M_i$  from Figure 2, one can easily show that the F/H ratio for the statues of the reduced heights  $M_0 - M_5$  (cut at the original *hami* level) and  $M_0 - M_4$  (sacrificing the whole bottom up to the level of the navel) will yield exactly  $382/910=0.420$  and  $382/854 = 0.447$ , which agrees well with the data presented in the Table 1.

Therefore, the main design elements of the monolithic Easter Island sculpture, considered in frontal/side projection, can be satisfactorily described with the set of the measures  $M_i$ , obtained by the repetitive golden section of a segment equal to the height of the statue. The resulting image was thus characterized by idealized harmonic proportions, which could be considered as enabling it to function properly as the spiritual vessel connecting the supernatural world with the realm of the humans. Subdivision coefficients, obtained in the framework of this hypothesis, can be used for the conjectural dimension reconstruction for the buried, eroded and broken-off parts of the *moai*.

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